



national accelerator laboratory

EXP-60
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ACCELERATOR EXPERIMENT--Improvement of 200-MeV Transport

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Summary

The continued use of the multiturn injection system and the impending installation of a linac debuncher cavity have made a better understanding of the operation of the 200-MeV transport system imperative. This study day was dedicated to reducing the quadrupole steering and to reducing the chromaticity of the 200-MeV transport.

The beam steering problem in two parts of the 200-MeV transport in the booster tunnel was reduced by the selective movement of several quadrupole magnets. The second improvement in the beam transport comes from an approximate factor of ten decrease in the vertical dispersion in the beam displacement between the linac to booster tunnel. A third feature is a demonstration of the much better understanding of the 200-MeV transport line exhibited by prediction of quadrupole strengths necessary to not only reduce the chromaticity but also to give a desired beam size in the debuncher area.

Quad Steering

Significant reduction in the quad steering was achieved in two parts of the 200-MeV line. At the bottom of the chute, quad 12 was moved up ~130 mils so that beam hitting the vertical center of quad 11 was also centered in quad 12. Likewise, the quads between the horizontal bend MH2 and the inflector, quads 20, 21 and 22, were moved horizontally 48, 115 and 65 mils respectively towards booster center so that beam is in the center of these quads when it is also centered on multiwire 8 just upstream from the injection septum magnet S2.

Comparison of Calculated Beam Widths with Measurements

A set of quadrupole currents was calculated to make the upstairs horizontal bend achromatic, to make the vertical displacement between the linac extension and booster tunnel achromatic and to produce a 2 cm diameter waist in both the horizontal and vertical planes at the new debuncher position (close to the present multiwire 6 position). These values were set in quads 6-15. The calculated beam widths are compared with the widths measured with the multiwire profile monitors in Figure 1.

The X's are the calculated widths using a measured 90% emittance beam area of 10π mm-mrad. The boxed X's are measured 90% profile widths that show up on the multiwire measurement display. Since a 90% profile width is not equivalent to a 90% emittance beam, the widths of the bases of the wire profiles are also shown in Figure 1 by small circles. Except for the horizontal width at wire 3 (the beam at this point was too wide for the multiwire) the predicted and measured widths are in substantial agreement. Figure 2 shows an arbitrary measured linac emittance with the width of the 90% emittance and the calculated 90% profile width shown on the inset profile. The profile width is only 77% of the width of the 90% emittance. This ratio, of course, depends on the detailed beam distribution and was worked out for the example shown. The profile base width is thus more comparable to calculated widths using a 90% emittance beam area.

Dispersion

The linac momentum was changed by varying the phase of tank 9. One higher momentum value and two lower values were used to study the chromatic properties of the line. Their dispersion was determined from the shift in beam position at each multiwire. Table 1 shows the measured dispersion for the three linac momenta after the calculated achromatic values for the quads were put in and the calculated and measured dispersion for the "nominal" quad currents used previously. Wires inside a translation should have a dispersive value other than zero in the plane of the translation. Thus, wires 1, 2, and 8 should have a non-zero value in the horizontal and 4 and 5 in the vertical. The agreement between the calculated and measured values for the "nominal" quad strengths is seen to be very rough.

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The horizontal values of the two lower momentum measurements are fairly consistent but the same values for the higher momentum measurement are quite different. Looking at wire one horizontal for the higher momentum, it seems likely that more than just the momentum of the linac beam changed. Running quad 6 at the achromatic value did not seem to give a measurable improvement in the horizontal achromatic properties of the line. The contribution to the dispersion by this quad should be small even with the older, slightly lower operating current. The vertical values for wires 6, 7 and 8 that are underlined in the table show a significant (approximately a factor of ten) improvement in the vertical achromatic properties of the line using the calculated quad currents.

One more dispersion measurement was made. This was the horizontal dispersion at wire 9 at the injection point to the ring. After the final tuneup of the booster, the calculated value was -1.299 cm/% and the measured value was -1.25 cm/% in unexpectedly good agreement with the calculation. This dispersion arises in the horizontal translation over to the injection area by MH2, S2, and the inflector. The location of the quads in this region was chosen to provide momentum matching to the booster for single-turn injection, which requires a dispersion of -1.84 cm/%. Changes in the quad arrangement are required to make this part of the line achromatic.

E. R. Gray

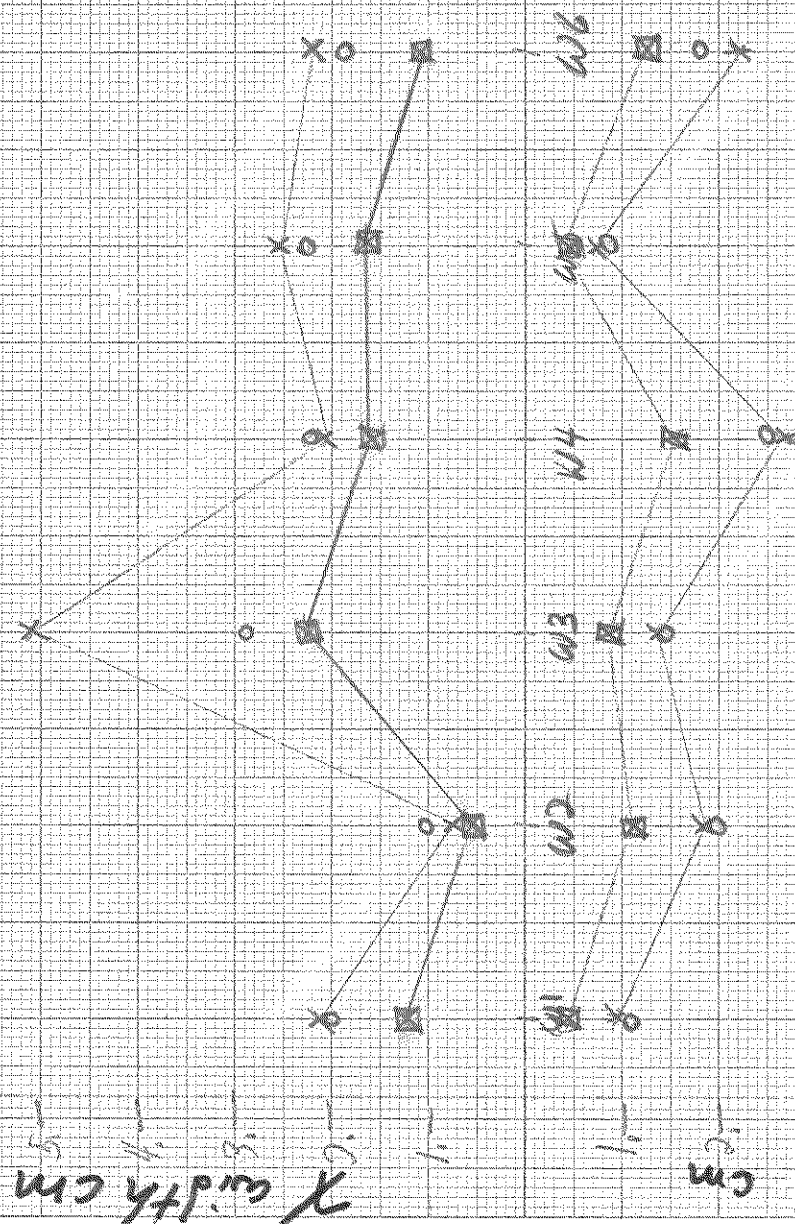
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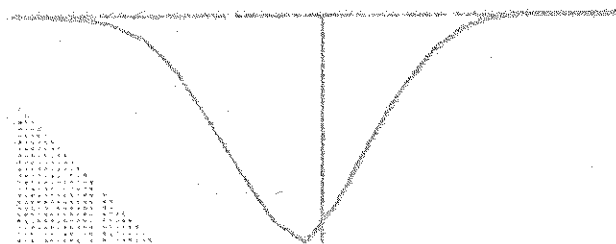
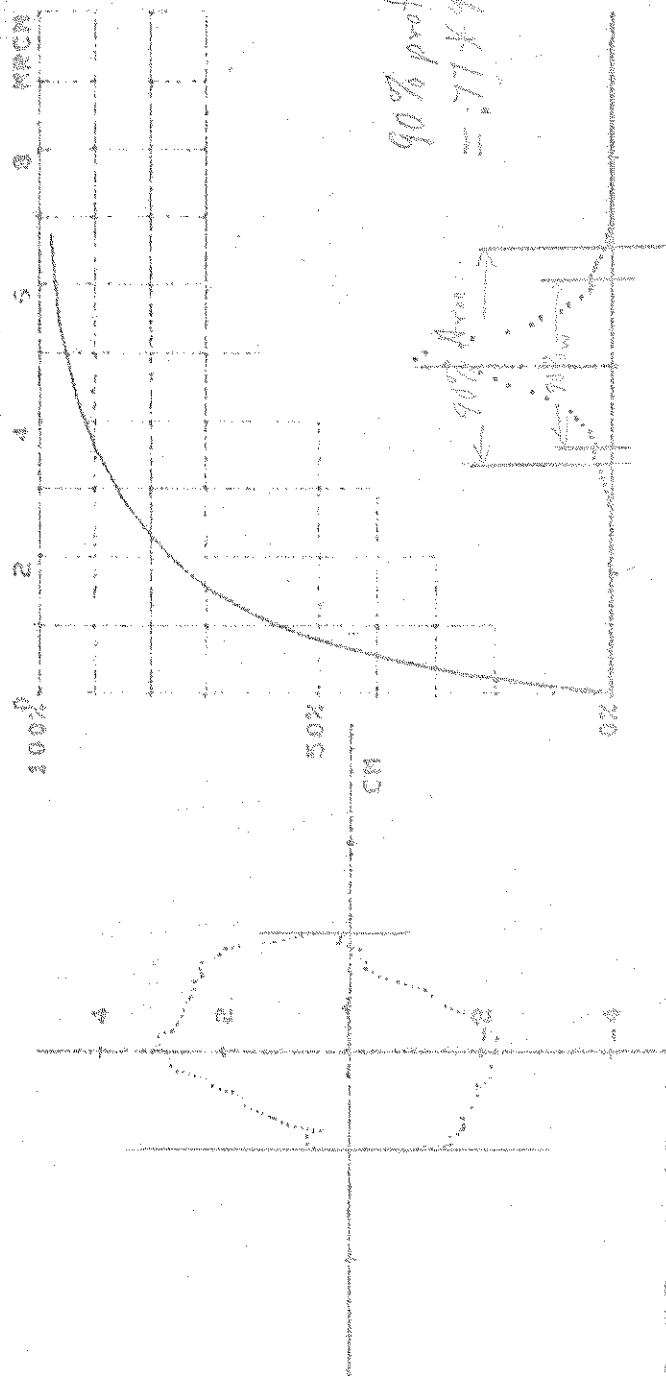
X Calculated for
1 cm radius waist
at New Deb

Measured with
Quad fields above
wire profile
90% width

Base of Mult wire
profile

Figure 1





100

Table 1

Dispersion Cn per percent

		Old Running Quad values				Measured for Calculated Quad values							
		Calculated		Measured		$\frac{\Delta p}{p} + .0374\%$		$\frac{\Delta p}{p} - .112\%$		$\frac{\Delta p}{p} - .198\%$			
		X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
W1		.287	0.	.337	.112	1.68	.134	-.160	.045	.010	.061		
W2		.203	0.	.019	.075	-.401	-.428	.267	.107	.187	.091		
W3		.279	0.	-.262	-.056	-2.17	-.187	.276	.000	.465	.051		
W4		-.180	1.067	-.131	.804	-.120	.535	.107	.856	.131	.813		
W5		-.206	1.814	+.187	3.911	-.136	.027	.784	-.009	-.111	.005		
W6		.594	<u>-4.89</u>	.486	<u>-3.12</u>	.642	<u>-.080</u>	-.499	<u>-.348</u>	.157	<u>-.247</u>		
W7		+.126	<u>-5.31</u>	.056	<u>-3.07</u>	.695	<u>-.321</u>	.143	<u>-.633</u>	.005	<u>-.616</u>		
W8		-1.89	<u>7.02</u>	-.973	<u>3.39</u>	-1.74	<u>1.15</u>	-.989	<u>-.285</u>	-1.00	<u>-.227</u>		